PROJECT

Supervisor: ____Prof. Lorenzo DAGNA_____

Title: Advanced imaging techniques to disclose and quantify lung involvement in Systemic Sclerosis-associated Interstitial Lung Disease

Curriculum: ____Experimental and Clinical Medicine_____

Link to the personal page of the University or relevant hospital site website: https://www.unisr.it/en/docenti/d/dagna-lorenzo

https://www.hsr.it/dottori/lorenzo-dagna

Description of the Project (max 3,000 characters including spaces)

Background/gap of knowledge

Systemic sclerosis (SSc) is a rare autoimmune disease marked by immune dysregulation, vasculopathy, and progressive fibrosis, often involving the lungs. Interstitial lung disease (ILD) is the most frequent and life-threatening visceral complication, with a 10-year mortality of up to 40%. The clinical course of SSc-ILD is highly variable, but around 30% of patients show progression within a year. Thus, early and accurate identification of patients at risk for progressive ILD remains a major unmet clinical need. High-resolution computed tomography (HRCT) is the gold standard for diagnosing and monitoring SSc-ILD, but repeated exposure to ionizing radiation is a concern, particularly in younger patients requiring serial assessments. Furthermore, conventional imaging struggles to distinguish inflammation from fibrosis or detect subclinical microvascular changes, limiting timely interventions. Magnetic resonance imaging (MRI) is radiation-free but often limited by long acquisition times and suboptimal spatial resolution.

Rationale and hypothesis

Emerging imaging modalities, such as photon-counting detector CT (PCD-CT) and high-field (3T) MRI, offer enhanced spatial resolution and functional characterization, with reduced radiation and scan times. Preliminary data from our center, in collaboration with the Unit of Experimental Radiology, suggest that PCD-CT can detect early ILD changes, including perfusion defects and vascular abnormalities, even without overt fibrosis. Similarly, optimized 3T MRI with

edema-sensitive T2 sequences may help differentiate inflammation from fibrosis. We hypothesize that imaging biomarkers derived from these techniques, enhanced with AI-driven analysis, can improve staging, prognosis, and monitoring of SSc-ILD.

Objectives and specific aims

The primary objective is to validate novel imaging biomarkers from PCD-CT and 3T MRI for characterizing and monitoring SSc-ILD.
Specific aims:

1. Compare complete PCD-CT and 3T MRI protocols in staging ILD severity and activity.

2. Identify imaging biomarkers of early fibrosis, inflammation, and microvascular damage to better quantify disease burden.

3. Determine which biomarkers best predict rapidly progressive ILD.

4. Assess the value of these biomarkers in predicting and monitoring treatment response.

Expected outcomes

This project aims to validate novel, non-invasive imaging biomarkers that detect early and active SSc-ILD, offering insights into the balance between inflammation and fibrosis. Using PCD-CT and 3T MRI may enable improved disease stratification, earlier identification of high-risk patients, and more accurate monitoring of therapy. These advances could minimize radiation exposure, guide personalized treatment, and improve patient outcomes. If validated, these imaging techniques could become future gold standards in clinical trials and routine care, aligning with precision medicine priorities and addressing key gaps in fibrosing lung disease management.

Skills that the student should acquire (max. 600 characters including spaces):

The student will acquire advanced skills in thoracic imaging, including PCD-CT and 3T MRI acquisition and interpretation, as well as expertise in radiomics, artificial intelligence, and quantitative image analysis. Moreover, she/he will also develop skills in clinical data integration, translational research methodology, and multidisciplinary collaboration across radiology, rheumatology, and pulmonology.

References (max. 15)

1) Denton CP, Khanna D. Systemic sclerosis. Lancet. 2017;397:1685-1699

2) Roofeh D, Brown KK, Kazerooni EA, et al. Systemic sclerosis associated interstitial lung disease: a conceptual framework for subclinical, clinical and progressive disease. Rheumatology

(Oxford). 2023;62:1877–1886

3) Ledda RE and Campochiaro C. High resolution computed tomography in systemic sclerosis: From diagnosis to follow-up. Rheumatol Immunol Res 2024

4) Hoffmann-Vold AM et al. The identification and management of interstitial lung disease in systemic sclerosis: evidence-based European consensus statements

5) Raghu G et al. Idiopathic Pulmonary Fibrosis (an Update) and Progressive Pulmonary Fibrosis in Adults: An Official ATS/ERS/JSR/ALAT Clinical Practise Guideline. Am J Respir Crit Care Med 2022

6) Jungblut L et al. Assessment of interstitial lung disease in a systemic sclerosis patient cohort using photon-counting detector CT with ultra-high resolution and a 1024 pixel image matric. Br J Radiol 2024

7) Jungblut L et al. Potential of Photon-Counting Detector CT for Radiation Dose Reduction for the Assessment of Interstitial Lung Disease in Patients With Systemic Sclerosis. Invest Radiol 2022.

8) Dupont A et al. Dual-energy CT lung perfusion in systemic sclerosis; preliminary experience in 101 patients. Eur Radiol 2023

9) Lanzetti L et al. Magnetic resonance imaging of interstitial lung disease: a state-of-art review. Respir Med 2019

10) Pinal-Fernandez et al. Fast 1.5 T chest MRI for the assessment of Interstitial Lung Disease extent secondary to systemic sclerosis. Clin Rheumatol 2016